
CORNELL UNIVERSITY
AGRICULTURAL EXPERIMENT STATION OF
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Department of Plant Pathology

PEACH LEAF CURL



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PEACH LEAF CURL.

Next to the apple, the peach is the fruit of the greatest commercial importance in the State of New York. It is grown most successfully near large bodies of water, such as the Great Lake Regions of Western New York. It is also extensively grown in some parts of the Hudson River Valley. It is very susceptible to injury induced by extremes of temperature, and is therefore especially favored by the tempering influences of bodies of water. In some seasons, however, in these localities weather conditions are such as to favor the development of fungous diseases, not the least destructive of which is the Leaf Curl.

The natural host plant for the fungus causing this disease is not certainly known. Certain it is, however, that at present the peach is everywhere the plant most commonly attacked. According to Pierce ('00) this malady "is confined almost wholly to the peach or its derivatives, as the nectarine and peach-almond." He further states that the disease has been noted on plum and almond but says this is rare.

THE DISEASE

Origin, history and geographical distribution.—As Duggar ('09) has pointed out, "Attempts to determine the country which might be regarded as the original home of this fungus have proved wholly futile. Leaf Curl is now a more or less common disease in nearly all peach-growing regions of the world. In North America it is known throughout the country, at least east and west, and from northern Canada to the Gulf of Mexico; while in South America it has also been reported from several peach-growing districts. In Europe it has long been common, having been reported in England as early as 1821, and it is disastrous in many sections of China and Japan. This disease occurs also in southern Africa, and from the Sahara northward in Algeria. According to reports it prevailed in Australia even in 1856, and it has proved most pernicious to peach-growing interests in New Zealand. In general, therefore, this disease is known wherever peach-growing is practiced. In the United States the general regions in which the more serious and constant injuries have been felt are apparently two, viz., the region of the Great Lakes and the Pacific Slope region, the latter including also districts in central and northern California."

'00. Pierce, N. B., Peach Leaf Curl; Its Nature and Treatment, U. S. D. A. Div. Veg. Phys. and Path., Bul. 20:18, 1900.

'09. Duggar, B. M., Fungous Diseases of Plants, Ginn & Co. N. Y., 1909:176 and 177.

Pierce ('00) collected a great amount of data on the geographical distribution of this disease. This is set forth in detail in the bulletin as indicated at the bottom of this page. Like many other fungous diseases it is of an epidemic nature, appearing with severity in any locality more or less regularly every four or five years. The epidemic periods of this disease in New York since 1893 appear from the records (Duggar '09, Orton '03, '04, '08, '09) to have been 1893, 1897-8, 1902-3, 1907-8. The direct correlation of these epidemics with certain weather conditions will be brought out later.

Economic importance.—The character of the injury from this disease is such as to render very difficult if not impossible an accurate estimate of the losses resulting from its ravages. In attempting to determine accurately such losses we are confronted with a number of difficulties. It cannot be computed from the evident effects during the season in which the attack occurs, since a severe attack of the disease may greatly reduce or prevent entirely the setting of fruit buds for the following season. Moreover the late growth of the shoots induced by the attempt to replace the leaves lost by the Curl early in the season often results in a failure of the wood to mature. Serious winter injury is likely to follow with the loss of the ends of the limbs or even of the entire tree. Then, too, the direct effects of the disease during the season in which it has appeared will vary greatly with conditions. The defoliation of the trees which follows as a result of the dying of the curled leaves, may be so complete as to cause the dropping of the fruit which has already set (Fig. 84). In other cases the trees may be in such good condition from proper cultivation, etc., as to be able to come through the attack with sufficient healthy foliage to hold and mature a part or all of the fruit crop. The effect of the disease upon the fruit crop and upon the vitality of the tree appears to depend not only upon the extent and severity of the attack but also upon the condition of the tree as determined by its vigor, location, and the character of the succeeding winter. Pierce ('00) made a very careful and extensive study of this phase of the subject and concluded that the average annual loss from Peach Leaf Curl in the United States could not be less than \$3,000,000. The very general practice of spraying for this disease in most peach sections

'00. Pierce, N. B., Peach Leaf Curl; Its Nature and Treatment, U. S. . A., Div. Veg. Phys. and Path., Bul. 20:12-19, 1900.

'03, '04, '08, '09. Orton, W. A., Plant Diseases in the U. S. U. S. D. A., Year Book for 1902:716; Year Book for 1903:550; Year Book for 1907:579; Year Book for 1908:535.

'00. Pierce, N. B., Peach Leaf Curl; Its Nature and Treatment, U. S. D. A., Div. Veg. Phys. and Path., Bul. 20:19-21, 1900.

has perhaps materially reduced that estimate for recent years. Still in seasons especially favorable to the disease, as 1908 and 1909, serious losses have been sustained by growers who had heretofore apparently controlled the disease very easily. A careful study of a number of such failures has lead us to the conclusion that in most cases want of thoroughness or the application of the spray at the wrong time has been the difficulty.

Varietal susceptibility.—It is well known to both growers and pathologists that some varieties of peaches are affected more frequently and more severely than others. The Elberta, for example, is so liable to this disease that it suffers more or less every season unless properly sprayed. Many of the other varieties commonly grown in this State suffer so little in ordinary seasons as to be regarded by growers as practically immune. However, in seasons especially favorable to the malady even these varieties may curl badly. As is usually the case, these less susceptible varieties are not so desirable commercially as is the very susceptible Elberta. Because of its commercial superiority and marked susceptibility to the Curl, the Elberta has been responsible for the very general and successful practice of spraying for the Curl in our commercial orchards. From the reports from a large number of growers in the State during 1908 and 1909, the following data on varietal susceptibility in New York have been compiled:

Of the growers reporting varieties *most* affected:

48 give Elberta *first* place.

4 " Elberta *second* place.

2 " Early Crawford *first* place, and 3 others give first place to Crawford, but do not specify whether Early or Late Crawford.

1 gives Early Crawford *second* or *third* place, and 1 gives merely Crawford, not specifying Early or Late.

4 mention Niagara as especially affected.

2 " Late Crawford.

2 " Old Mixon.

2 " Reeves Favorite.

1 mentions Wager.

1 " Yellow St. John.

1 " E. River.

1 " FitzGerald.

1 " Champion.

1 " Stevens.

Of the growers reporting varieties *most* affected:

- 1 mentions Smock.
- 1 " St. John.
- 1 " E. Emma.
- 1 " Mt. Rose.

Of the growers reporting varieties *least* affected:

- 12 give Early Crawford *first* place.
- 6 " Crawford (Early or Late not specified) *first* place.
- 4 " Late Crawford *first* place.
- 1 gives Late Crawford *second* place.
- 5 give Crosby *first* place.
- 5 " Crosby *second* place.
- 4 mention Smock as but slightly affected.
- 3 " Niagara.
- 2 " Elberta.
- 2 " Chair's Choice.
- 2 " Hill's Chili.
- 2 " Solway.
- 3 " St. John.
- 1 mentions Stevens.
- 2 mention Wager.
- 1 mentions Clifton Park, Mt. Rose, White, FitzGerald, Late white peaches, early varieties.

Of the growers reporting varieties *not at all* affected:

- 3 give Early Crawford.
- 1 gives Yellow St. John.
- 1 " White.
- 1 " Mt. Rose.

It will be observed that no variety is universally reported immune. In fact, it appears that with only one variety, the Elberta, is there anything like a general and uniform experience among these growers.

Symptoms.—The symptoms of this disease are so well known to growers that a detailed description is hardly necessary. The abnormally swollen, thickened and distorted leaves, as shown in Figure 79, is a familiar sight to every grower of peaches. The disease often affects the shoots (Fig. 80), causing them to swell and cease growth, even killing them frequently. Losses from this disease by infection of buds in nursery stock may be quite heavy. Ten per cent were thus ruined in one nursery examined during the spring of 1909 (Fig. 79). The



FIG. 79.—*Showing the effects of the disease on the leaves and stem of budded nursery stock.*

flowers and young fruit may also be affected, but as these soon drop from the trees this is seldom observed by the grower. The affected leaves not only curl and thicken but become sickly yellow in color often tinted with red. After a few weeks these leaves fall from the trees (Fig. 84), in severe cases leaving them nearly or quite denuded of foliage, and that at a time of year when the tree can ill afford to lose them. It is true that a new crop of leaves is soon produced, but this effort of nature to repair the loss is disastrous in that it is a heavy drain on the vitality of the tree.



FIG. 80.—A comparison of twigs; a, healthy twig; b and c, twigs in which the Leaf-Curl fungus is wintering; d, twig killed by the fungus.

Etiology.—This malady, like most diseases of trees, is caused by a fungus that lives as a parasite in the affected parts. The name applied to this particular fungus is *Exoascus deformans*. This name, which at first appears rather formidable, is really descriptive. “*Exoascus*” refers to the fact that the spore sacs or asci of the fungus are borne free and uncovered over the diseased surface of the leaf (Fig. 81), while the last name, “*deformans*,” refers to the characteristic deformity of the leaf produced by this particular species (Fig. 79).

Just how this parasite enters the young leaves and shoots is not known. Certain it is that entrance into the host is effected very early

in the development and opening of the bud in the spring. This is proved by the fact that spraying before the buds swell will prevent the disease, while if the application is made after the tips of the leaves show, the disease is seldom well controlled.

Circumstantial evidence indicates that spores of the fungus are harbored through the winter most probably on or between the bud scales. When the buds swell the tender leaves within are thus exposed and if rains come at this time the spores probably germinate, sending forth

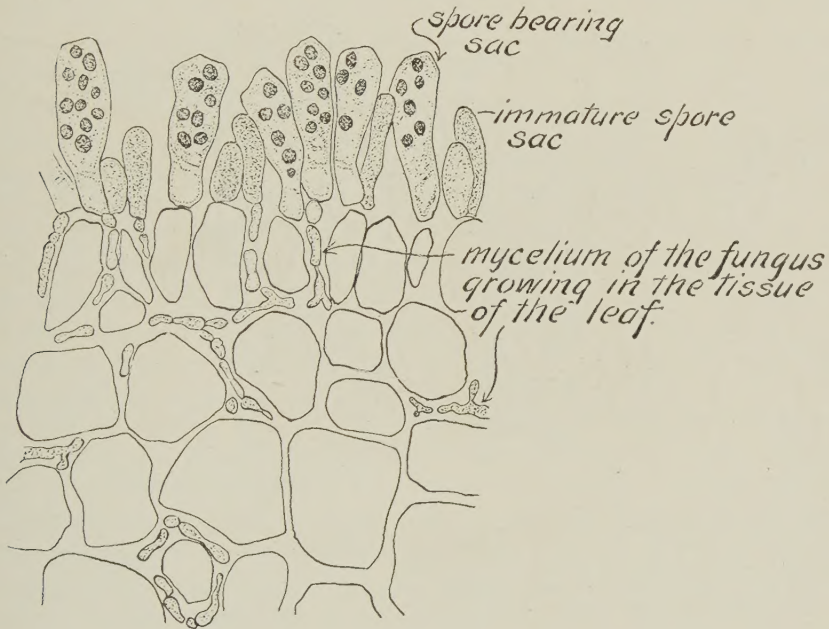


FIG. 81.—Cross section of a diseased portion of a leaf, showing the fungus and its relation to the leaf tissue. Highly magnified.

a germ tube which penetrates the young leaves within, thus establishing the fungus. Evidence of the presence of the parasite, even before the protruding leaves unfold, is often to be found in the reddish puffs or spots on the young leaves.

Thin cross-sections through a diseased leaf will show an abundance of the root-like mycelium of the fungus. (Fig. 81.) This mycelium irritates the growing cells of the young leaf, causing an evident increase in the number and size of the cells, as well as marked changes in their form and structure (Fig. 82). These changes are apparently very favorable to the growth and development of the parasite, but are most

unfavorable to the host. A thickening of the leaf results. The numerous tiny green bodies (chloroplastids) which in the healthy leaves fill most of the cells and take an important part in the manufacture of food in the tree, are not found in the affected cells. This accounts largely for the yellowish color of the diseased parts.

The ramifying mycelium finally pushes up (Fig. 81) between the epidermal cells and grows out under the thin transparent cuticle or protective coat of the upper surface of the leaf. This subcuticular mycelium branches and spreads in all directions. From this mycelium the

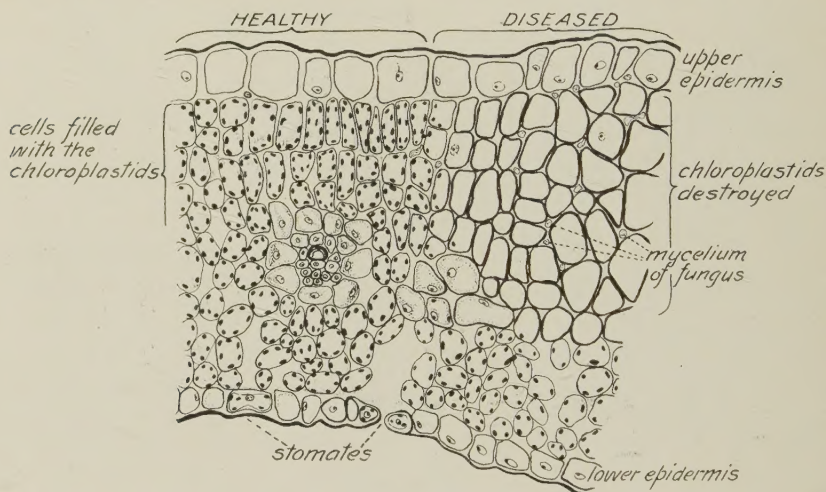


FIG. 82.—Cross section through a peach leaf along the line of diseased and healthy tissue. Note the increase in size and number of cells in the diseased portion and the marked absence of the leaf-green bodies or chloroplastids. It is the increase in the number and size of the long cells just under the upper epidermis that causes the thickening and curling of the leaf. (Drawing with camera lucida.)

asci are now produced (Fig. 81). These stand up in a layer all over the diseased surface, pushing off the cuticle and giving the leaf a frosty white appearance. In each of these asci are produced eight globose spores. These frequently increase greatly in number by budding so that an ascus may contain many small spores instead of the eight relatively large ones. The upper end of the ascus now opens and the spores are dispersed. In this State the maturing and dispersal of these spores occurs usually during May. What becomes of them, how they pass the summer and following winter is not known or at best only surmised. Since only the first few leaves that develop are affected it seems that these spores play little or no part in spreading the disease during the spring in which they mature.

This phase of the life history of the fungus offers a most interesting problem for further investigation.

Ecology.—The conditions favoring the development of the disease have been carefully studied. Pierce ('00) collected much data in regard to the relation of the weather to the development of the curl. Selby ('99) also made a careful study of the same phase of this subject. Many growers have noticed that Curl is favored by cold, wet weather while the leaves are opening. Naturally this has led many to consider such weather conditions to be the cause of the disease. The cause, however, is not the "weather" but the fungus. The growth of the fungus and infection of the host by it are favored by the conditions above stated, for several reasons. The low temperature and moist atmosphere incline to check transpiration from the leaf out of all proportion to the absorption of water by the roots from a relatively warm soil, consequently the leaf tissue becomes abnormally gorged with water, causing a succulent, watery growth less able to resist the attack of the fungus. It is true also that the same conditions which render the host most susceptible are most favorable to growth of the fungus causing the disease. In fact, any condition favoring a superabundance of moisture is, in general, most favorable to the spread and growth of this as well as most fungi. For this reason peach orchards situated near large bodies of water are more likely to be severely attacked by Curl. The direction of prevailing winds also has an influence. When blowing from dry regions they bring much less moisture than when coming over a large lake or ocean. Professor Pierce believes that heavy dews have little or no effect in inducing Curl. They do not weaken the vitality of the leaf, since they occur at night while transpiration is normally low and the stomates almost closed. He also asserts that something more than dew is necessary to cause germination of the spores of *Exoascus deformans*.

CONTROL OF THE DISEASE

No one would suspect from what we actually know of the life history of this fungus that spraying during the dormant period would be successful in preventing the disease. Perhaps we would still be ignorant on this point if the California growers had not long ago noticed that Curl was almost entirely controlled on trees sprayed with lime-sulfur

'00. Pierce, N. B., Peach Leaf Curl; Its Nature and Treatment, U. S. D. A., Div. Veg. Phys. and Path., Bul. 20:22-30, 1900.

'99. Selby, A. D., Variations in the Amount of Leaf Curl of the Peach (*Exoascus deformans*) in the Light of Weather Conditions, Proc. Soc. Prom. Agr. Sci., Ann. Meeting 20:98-104, 1899.

in winter for San José Scale. Just where and how the spores are carried over is, as pointed out before, an unsettled question. It seems probable that they are lodged on the twigs or bud scales. Farrand ('04) found that Curl was prevented on trees sprayed with copper sulfate and drenched with water an hour later to wash off the spray. From this



FIG. 83.—A branch from a tree sprayed early with bordeaux mixture.

and from the fact that spraying at almost any time during the dormant period seems effective, it would seem that the spores are at once killed by the fungicide. The early students of this disease were skeptical concerning the possibility of controlling it by spraying. This conclusion was drawn from the opinion generally held at that time that the disease was carried over by perennial mycelium in the twigs. For this reason it was advised by many to cut back diseased shoots, and even the removal of diseased leaves was proposed by some. These measures were found to have very little or no effect in controlling the disease, and it has since been learned that the conclusion that the parasite wintered in diseased twigs to any extent was erroneous, since the percentage of Curl carried over by mycelium in the twigs is

extremely small. A very complete account of this and of the development of the present methods of treatment is given by Pierce ('00). According to his statement the practice of spraying for Curl during the dormant period dates to observations made in California on the effect of lime-sulfur solution as used for San José scale. This preparation, so the

'04. Farrand, T. A., Mich. Report of South Haven Sub-station for 1903, Special Bul. 27: 17.

'00. Pierce, N. B., U. S. D. A, Div. Veg. Phys. and Path., Bul. 20:46-65.

story goes, had first been used in Australia as a sheep dip for scab. Soon after the outbreak of San José scale in California, certain persons were induced to use lime-sulfur for its control on peach trees; and as early as 1883 or 1885 it was in general use for this purpose in certain sections. It was soon noticed that trees treated in this way did not suffer from Curl; and from this developed the practice of spraying early in the spring before the leaf buds open. Since that time it has been repeatedly demonstrated that a single early application of either lime-sulfur solution, bordeaux or copper sulfate will satisfactorily control the disease. (Figs. 83 and 84.)

The *important factors* in the control of this disease seem to be (1) time of application, (2) thoroughness, and (3) the fungicide used. This statement represents also, we believe, the order of importance of these three factors.

(1). *Time of application.*—

This is to be determined primarily by the condition of the buds, although in some cases the character of the weather is also to be considered. In general it is desirable to spray before the buds “start” or swell in the spring. Evidently

any time within a month prior to swelling of the buds is satisfactory. If for any reason spraying has been delayed until buds have begun to swell, then the application to be effective must be applied before any protracted period of cold rain ensues. There appears to be no doubt that many failures reported the past two seasons were due to late spraying following instead of preceding a rainy period. *Spray before rain periods, not after.*

(2). *Thoroughness* is a relative term. Every man who sprays is thorough, or thinks he is, or at least tries to be, yet a thorough job



FIG. 84.—A branch from a tree sprayed late with bordeaux mixture.

cannot be done by spraying with the wind from one side of the tree. It may be impossible to spray from both sides of the tree for one reason or another. One should not then expect perfect results or at least not blame the fungicide used. It is possible to spray a tree until the solution runs down the trunk and yet not do thorough work. The tips of the branches may not have been touched or those buds on the opposite side of the tree from which the spray was applied may have received little or no coating, even though a stream of the spray mixture ran down the twig on the side toward the nozzle. High pressure is an important factor in thoroughness. *The only immediate test of thorough work is to find no buds on the trees that are not entirely covered with an evenly distributed coat of the spray mixture.*

(3). *The fungicide used and the strength of it are of relatively little importance.* Repeated experiments have shown that bordeaux mixture 5-5-50 to 3-4-50 will control Peach Leaf Curl (Fig. 83). Lime-sulfur, home-boiled, or commercial concentrate of almost any brand, will do the work. The senior author showed last year that a commercial concentrate (Niagara Brand, heavy grade) testing about 32° Baume, diluted as much as 1-20, was fairly effective in controlling Curl. Duggar ('99) tells of the complete control of this disease by the use of lime alone (plain white wash) applied during January and February. Farrand ('04) shows that 2 pounds of copper-sulfate alone in 50 gallons of water is also entirely effective for Peach Leaf Curl. Since San José scale is now very generally distributed and lime-sulfur therefore commonly used as a winter spray, it is evident that lime-sulfur will be the commonly used specific for Leaf Curl in most of the orchards of the State. In any case failure to control the disease should be laid to the fungicide only as a last resort. It is seldom the controlling factor in such failures.

Reports of growers on the control of this disease.—Thinking that a brief summary of the experiences of growers in this State in combatting the Leaf Curl might be of interest, circular letters were sent out asking for reports on their work with this disease during both 1908 and 1909. A total of 71 reported for 1908 and 14 for 1909.

'99. Duggar, B. M., Peach Leaf Curl, N. Y. (Cornell) Sta. Bul. 164: 381-382.

'04. Farrand, T. A., Report South Haven Sub-station for 1903, Mich. Sta. Spec. Bul. 27:17-18.

The following tables compiled from these reports are interesting:

Time of application

TABLE I.—RESULTS REPORTED BY GROWERS ON TIME OF APPLICATION
For 1908

Condition of buds when sprayed	Complete control	Good results	Fair results	Poor results	Failure
Dormant	5	11	1	..	..
Swelling	2	6	3	1	..
Opening	..	..	..	1	..
Just started	..	..	..	..	1
Dates of application					
March	1	4	..	..	1
Apr. 1-15	4	9	3	1	..
Apr. 15-May 1	1	1	..	..	..

For 1909

Condition of buds					
Dormant	2	2	1	1	1
Swelling	2	1	..	..	..
Opening	1	..	..	..	..

It will be observed from the above table that of the 17 in 1908 reporting the application while buds were dormant none had poor results, while among those reporting application after buds began to swell there were some poor results. That these failures may not have been due to the late application is possible, since in 1909, of the few reporting in regard to time of application, at least two had poor results from spraying during the dormant period. The evidence of the growers therefore, based upon their experience, is in favor of early spraying while the buds are still dormant.

*Fungicides used*TABLE II.—RESULTS REPORTED BY GROWERS ON SPRAY MIXTURES USED
For 1908

Spray used	Number reporting complete control	Good results	Fair	Poor	Failure	Successful* %
Bordeaux.....	6	27	6	5	2	84.7
Lime-sulfur mixtures...	6	13	1	..	1	95.2
Copper Sulfate.....	..	2	..	1	..	..
Scalecide 1-11.....	..	1	..	..	..	..
No spray used.....	5 report severe injury from curl, 1 less than in 1907, and one reported that he had better fruit than neighbors who sprayed. Another has raised \$10,000 worth of peaches and never sprayed.					

For 1909

Spray used	Number reporting complete control	Good results	Fair	Poor	Failure	Successful* %
Bordeaux.....	2	5	..	1	1	77.7
Lime-sulfur mixtures...	3	1	..	1	..	80

SPECIAL FORM OF BORDEAUX AND LIME-SULFUR USED '08 AND '09

Rex lime-sulfur.....	..	2	..	..	..	..
Niagara lime-sulfur....	1	..	..	..	..	..
Grasselli lime-sulfur....	1	1	..	1	..	..
Lime-sulfur-salt.....	1	1	..	..	..	..
Home-boiled.....	1	2	..	..	..	..
Lime-sulfur, kind not specified.....	5	7	1	1	1	..
Prepared bordeaux....	..	1	..	..	..	..

* Successful includes those reporting complete control, good and fair results.

The bordeaux varied from 3-5-50 up to 6-10-50: good results usually reported for all concentrations.

From the above summaries it is evident that the spray mixtures used were about equally effective and the failures recorded must be

attributed to some other factor. This again emphasizes the fact that in spraying for Leaf Curl the character of the fungicide is too often over-emphasized. It is the least important of all the factors involved in the successful control of this disease.

TABLE III.—RESULTS OF SPRAYING, REGARDLESS OF METHODS OR MATERIAL USED
For 1908

Total reports included	Good or complete results	Complete control	Fair	Poor	Failure	% complete or good	% complete	% good complete or fair	% poor or failure
1	55	12	7	6	3	78.5	16.9	87.3	12.6

For 1909

14	11	5	..	2	1	..	..	..	..
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Summary for 1908 and 1909

85	65	17	7	8	4	77.6	20	85.4	14.1
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Out of a total of 71 reports received in 1908, 55 (78%) report good results from spraying, regardless of methods or material used. Twelve of these (16%) report complete control, and 7 fairly good. This gives a total of 87% of the reports ranging from good to fair, while only 9 (12%) reported poor results. Three of these stated that no benefit whatever had been derived from the treatment.

For 1909 a small number of reports were received: 11 report good results (including 5 getting complete control), 2 poor results, and 1 no success.

From the above summaries of the reports of growers themselves during two severe Leaf-Curl seasons, it is safe to say that spraying for Peach Leaf Curl is a successful orchard practice among the peach growers of this State. Of all the factors involved, the man who does the spraying is the most important, and to him is to be properly laid, in most cases, such failures as result. No peach grower who grows varieties susceptible to Curl can afford to neglect to spray.

It has also been clearly demonstrated that the application to be effective must be given early, before the buds are too far advanced. There is much discussion at present as to which is the most effective spray to use. Bordeaux mixture and lime-sulfur solution have both been used successfully.

Experiments with lime-sulfur for control of the Curl ('09).—During the spring of 1909 some experiments were conducted with a view of obtaining some data relative to the comparative value of bordeaux and lime-sulfur and what dilution of the latter can be most profitably used. The work was conducted by the senior author in the orchard of Mr. L. B. Frear of Ithaca, who placed his orchards and spraying apparatus at our disposal, provided room for a field laboratory and helped in many ways to conduct the investigation of this as well as other diseases of orchard fruits. The lime-sulfur solution used was the Niagara Brand, heavy grade, some that Mr. Frear had purchased early in the season.

The bordeaux was made according to the 3-3-50 formula. The experiments were conducted in two of Mr. Frear's orchards, situated three miles apart; one near Ithaca, N. Y., the other near Jacksonville, N. Y. The applications were made April 5th to 12th. A strong wind was blowing in every case, which made it impossible to thoroughly coat all sides of the twigs as should have been done to insure perfect eradication. From June 19th to 21st, the leaves on several limbs from each of a number of trees, receiving the different treatments, were counted to determine the percentage of Curl. The branches for counting were chosen at random. In order to avoid any possible selection, each branch was chosen with eyes closed. In the large numbers thus chosen, the estimate should conform very well to the law of averages. The results are recorded in the following tables. The east side of the Jacksonville orchard was sprayed April 9th with the lime-sulfur, diluted 1-9. A check row was left unsprayed. No bordeaux was used in this orchard. The table shows the lime-sulfur to have controlled the Curl almost entirely. Figures 85 and 86 are photographs of sprayed and unsprayed trees growing side by side on these plats.

RESULTS OF SPRAYING FOR PEACH LEAF CURL IN THE JACKSONVILLE ORCHARD

TABLE NO. I

East side sprayed April 9, 1909

Treatment	Number trees included	Number limbs selected	Number leaves counted	Number leaves curled	Number leaves healthy	% leaves curled
Not sprayed	4	14	1120	660	460	58.9
Sprayed lime-sulfur 1-9	6	22	1933	18	1915	.9

'09. Wallace, E., Peach Leaf Curl and Its Control, Niagara Sprayer Co. Fellowship, First Report 6-8, Oct. 19, 1909.



FIG. 85.—*Unsprayed.*



FIG. 86.—*Sprayed with lime-sulfur.*

The western side of the same orchard sprayed April 12, 1909 (see table No. 2 below) shows that the results here were not quite so striking. Although well controlled, there was a small percentage of Curl.

TABLE NO. 2

West side of Jacksonville orchard, sprayed April 12, 1909

Treatment	Number trees included	Number limbs selected	Number leaves counted	Number leaves curled	Number leaves healthy	% leaves curled
Not sprayed	4	15	1699	584	1115	34.3
Sprayed with lime-sulfur 1-12	4	26	2574	105	2469	4.1
Sprayed with lime-sulfur 1-15	5	22	1987	46	1941	2.3
Sprayed with lime-sulfur 1-20	5	30	3292	204	3088	6.1

In the Ithaca orchard the experimental plats consisted of about 200 trees. One row was sprayed with lime-sulfur 1-9, leaving five trees unsprayed as a check. The second and third rows were sprayed with lime-sulfur 1-15; and the fourth, fifth and sixth rows, with bordeaux 3-3-50, leaving four check trees. Table No. 3 gives the results.

TABLE NO. 3

Showing results of spraying for Peach Leaf Curl in the Ithaca orchard. Sprayed April 7, 1909. Results taken June 19, 1909

Treatment	Number trees counted	Number branches counted	Number leaves counted	Number leaves healthy	Number leaves diseased	Total % diseased
Not sprayed	4	28	2227	1307	920	41.3
Sprayed lime sulfur 1-9	4	27	3568	3355	213	5.9
Sprayed lime-sulfur 1-15	4	35	5102	4829	273	5.3
Sprayed bordeaux 3-3-50	5	37	5113	4687	427	8.3

Several points should be noticed especially in connection with these tables. First, according to table No. 3, the lime-sulfur 1-15 certainly controlled the Leaf Curl as well as the 1-9, which has usually been recommended for the Curl. Unless it is necessary to combat scale this

greatly reduces the cost of material. Even the 1-20 (table No. 2) compared fairly well with the stronger solution. Table No. 3 shows some advantage in favor of the lime-sulfur treatment as compared with bordeaux, the total percentage of diseased leaves being reduced from 41.3 to 5.3 by the lime-sulfur diluted 1-15, and to 8.3 on the bordeaux plat. The difference was great enough to be noticeable without counting. The application was made the same day and impartially.

During the present season many growers have used the lime-sulfur for Peach Leaf Curl with almost perfect results. Some unfavorable reports must be expected from any treatment. In such cases, however, there must be something wrong in the method or time of application. It has been demonstrated beyond doubt that proper spraying will satisfactorily control the disease. A strong point in favor of lime-sulfur as compared with bordeaux mixture is its value as an insecticide. Of course no sane man who has to combat San José scale would go to the extra expense of an application of bordeaux for Curl. Yet, even where Scale is not known to be present, the use of lime-sulfur for Curl acts as an insurance against it, and may prevent the latter from gaining a foothold unnoticed in some part of the orchard. We have found San José scale in several orchards where the owners were not aware of its presence. In many cases this pest becomes well established in and distributed throughout an orchard before being detected. Spraying with lime-sulfur for Curl may in many cases prevent much loss from the scale also.

In our experiments only the commercial lime-sulfur solution was used. There are in use at present several distinctly different kinds of lime-sulfur preparations: First, the home-boiled dilute solution, prepared in dilute form for immediate application as used for San José scale. Second, the self-boiled mixture as prepared by W. M. Scott ('10) of Washington, D. C., used especially as a summer spray to control Brown Rot of the peach and other fungus diseases. This is prepared without artificial heat for boiling, depending for its fungicidal properties on the sulfur in mechanical suspension. Third, the home-boiled concentrated solution as prepared by Cordley ('00) of Oregon, Stewart ('09) of Pennsylvania, and Parrott and Van Slyke of Geneva ('09). This is very similar in nature and composition to the factory boiled preparation and can be prepared as a stock solution to be diluted and

'10. Scott, W. M., & Ayres, T. W.. The Control of Peach Brown Rot and Scab, U. S. D. A., Bu. Pl. Ind. Bul. 174:15-16.

'00. Cordley, A. B., Rural New Yorker, March, 1909:202.

'09. Stewart, J. P., Penn. State College, Bul. 92:12-14.

'09. Parrott, P. J., Van Slyke, L. L., N. Y. Geneva Bul. 319 & 320:12.
(Pop. Ed.)

used throughout the season. Fourth, the commercial concentrated lime-sulfur solutions boiled under factory conditions. In all except the self-boiled mixture, lime and sulfur are boiled together, the calcium combining chemically with the sulfur in various proportions to form a soluble product. The dilution of a concentrated preparation for a certain purpose must be governed by the density of the solution used. This can most readily be obtained by the use of a Baume or a specific gravity hydrometer. For example, we used with good success Niagara lime-sulfur solution which tested about 32° Baume, 1.285 specific gravity, diluted 1-15. A grower may wish to know how he can dilute a home-boiled solution equivalent to this. Reference to table 4 below will help to solve such problems. In the case cited above the specific gravity of the diluted solution was about 1.019, or between 2° and 3° on the Baume scale. It is probable, therefore, that a home-boiled concentrated solution prepared according to Cordley and Stewart diluted to this density would have approximately the same fungicidal value as the commercial solution which we used diluted 1-15.

TABLE NO. 4
Giving Dilutions to Various Concentrates

Degrees Baume concentrate	No. times diluted for Leaf Curl only	No. times diluted if Scale is present*
35.....	1-16 $\frac{1}{2}$	1-9
34.....	1-16	1-8 $\frac{1}{2}$
33.....	1-15 $\frac{1}{2}$	1-8
32.....	1-15	1-7 $\frac{3}{4}$
31.....	1-14 $\frac{1}{2}$	1-7 $\frac{1}{2}$
30.....	1-14	1-7
29.....	1-13 $\frac{1}{2}$	1-6 $\frac{3}{4}$
28.....	1-13	1-6 $\frac{1}{2}$
27.....	1-12 $\frac{1}{2}$	1-6
26.....	1-12	1-5 $\frac{3}{4}$
25.....	1-11	1-5 $\frac{1}{2}$

* Dilutions for scale after Van Slyke, L. L. and Parrott, P. J., N. Y. Geneva Bul., 319 & 320:10, Pop. Ed.

Formulae and directions for preparing lime-sulfur solutions, bordeaux mixture, etc., for control of Peach Leaf Curl.

I. *Home-boiled dilute solution.*—This is the common home-boiled lime-sulfur 15-20-50 formula, which has been much used by growers for the control of San José scale. As applied for scale it is effective against Peach Leaf Curl.

II. *Home-boiled concentrated solutions of lime sulfur*.—Professor A. B. Cordley of Oregon was the first man to devise a home-boiled concentrate. His directions for preparing this solution, given in "Better Fruit" for April, 1909, p. 33, are as follows:

Sulfur, best, finely ground.....	110	lbs.
Lime, best grade, unslaked.....	60	"
Water sufficient to make.....	60	gals.

Slake the lime, mix the sulfur into a thin paste with a little water, add enough water to make 60 gallons, bring to a boil and boil for one hour. The sediment is then allowed to settle, after which the clear, dark amber-colored liquid is drawn off and may be stored in casks for future use. This, according to Cordley, should test from 26° to 32° Baume. It should accordingly be diluted from about 1-11 to 1-15 for Peach Leaf Curl, according to table 4.

The directions for the preparation of home-boiled concentrated solution as given by Van Slyke and Parrott ('09) are quoted below:

"For making the concentrated mixture the steps are the same as in making the usual boiled wash, but 60 lbs. of lime and 125 lbs. of sulfur are used for 50 gallons of solution. Slake the lime, make a thin paste, and add the sulfur. Flowers of sulfur or light or heavy sulfur flour may be used. The lime should be fresh lump lime, free from dirt and grit, containing 90% or more of calcium oxid and less than 5% of magnesium oxid. Stir thoroughly during the hour of cooking to break up the lumps of sulfur. Enough water should be added at the start so that evaporation will not leave the quantity less than 50 gallons when the cooking is ended. If kettles are used, 10 to 15 gallons additional will be needed, while with steam none may be required. The kettles should be considerably larger than the amount of wash to be made to prevent loss of material by boiling over. The clear liquid should be drawn off into tight containers if to be kept any considerable time; and stored where there is no danger of temperatures much below freezing."

III. *Commercial concentrated solution*.—There are a large number of proprietary brands of these concentrates now on the market and used by growers in this State. Most of these are clear, amber-colored solutions, though at least one company puts out a so-called "heavy grade" containing sediment. These concentrates should test about 32° Baume. In testing solutions containing sediment the reading should be taken

'09. Van Slyke, L. L. & Parrott, P. J. N. Y. Geneva Bul. 319 & 320: 12. (Pop. Ed.)

only in the clear solution above the sediment after thorough settling or filtering. It is very probable that any of these commercial solutions testing 32° Baume will entirely control Peach Leaf Curl at dilutions of 1-9 to 1-15 or even weaker. For data in regard to the chemical composition and relative value of different brands the grower is referred to the recent bulletin on "A Chemical Study of the Lime-Sulfur Wash" by L. L. Van Slyke, C. C. Hedges and A. W. Bosworth of the New York State (Geneva) Exp. Sta., Geneva, N. Y.

IV. *Bordeaux mixture*.—To prepare the mixture dissolve 4 lbs. of copper sulfate in about 30 gallons of water by suspending the crystals in a gunny sack just beneath the surface of the water, as the dissolved vitriol settles quickly to the bottom. Prepare the lime (4 lbs.) by slaking it with hot water, adding the water slowly so that the lime crumbles into a fine powder. When completely slaked, i.e., entirely powdered, add 5 or 6 gallons of cold water to make a rather thin milky solution. When the vitriol is all dissolved, stir it thoroughly and pour into it the lime milk which has been thoroughly stirred. Add enough water to make 50 gallons. One solution, preferably the copper sulfate as indicated above, should always be much diluted. *Never pour together two strong solutions and then dilute afterwards.* Never pour together the two solutions until ready to use. It is well to strain the mixture as it goes into the sprayer to take out anything that might clog the nozzle. Do not use tin or iron vessels in making the bordeaux. They will be eaten by the copper sulfate.

When large quantities of bordeaux are to be made, prepare concentrated stock solutions by dissolving the copper sulfate at the rate of two pounds to the gallon and slake the lime one pound to the gallon of water. Dilute 2 gallons of the vitriol solution in 30 or 40 gallons water and add 4 gallons of the lime solution. Add water to make 50 gallons.

V. *Copper sulfate solution*.—Dissolve 2 lbs. copper sulfate in 50 gallons of water by suspending the crystals in a gunny sack just beneath the surface of the water.